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CANTILEVER SCALES FOR MEASURING WEIGHT CHANGES

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ABSTRACT: Information on weight changes of a material or object with time is useful in many kinds of studies. A weighing device using a cantilever beam and load cell has been developed to provide an electrical readout of weight changes with time. Its capacity and sensitivity can be easily varied. The principles used in construction can be adapted to a wide range of load cell sizes and weighing uses.

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RETRIEVAL TERMS: combustion research; fuel consumption; burning rate; burning time; load cells; weight indications.

In fire research, it is often necessary to determine the burning rate of a fuel. This information is needed in studies of fire behavior, chemical retardants, air pollution, wildland fuel modification, and slow burning plant evaluation.

Burning rates are usually determined by placing the fuel on some sort of weighing device and recording the change in weight as the fuel burns. If a continuous record of the weight loss is desired, electrical weighing devices, such as strain gages or load cells, are used. The usual procedure then is to build a weighing platform supported at each corner by a load cell or strain gage. The electrical signal is recorded on a strip chart recorder or magnetic tape to record weight loss over time. This procedure generally works well, but is relatively expensive. Four electrical weighing units are required. And often the amount of fuel to be burned varies widely from one series of experiments to the next. In this case more than one set of weighing units would be needed because those capable of weighing heavy loads do not have the fine resolution needed for accuracy when the loads are small.

Since simple, low-cost weighing devices capable of recording weight losses during combustion were not available, we designed one using a single load cell and provided means of varying the load capacity and response sensitivity. Three units of varying sizes have been built to cover a wide range of weighing requirements. The materials needed can be easily obtained—most can be found around a machine shop. None of the dimensions of the device are critical. And construction is not difficult for anyone with mechanical ability. The units we built were for fire research. The same principles of design can be used for a wide range of load cell sizes, however, and the weighing device can be used for any purpose where weight change with time must be monitored.

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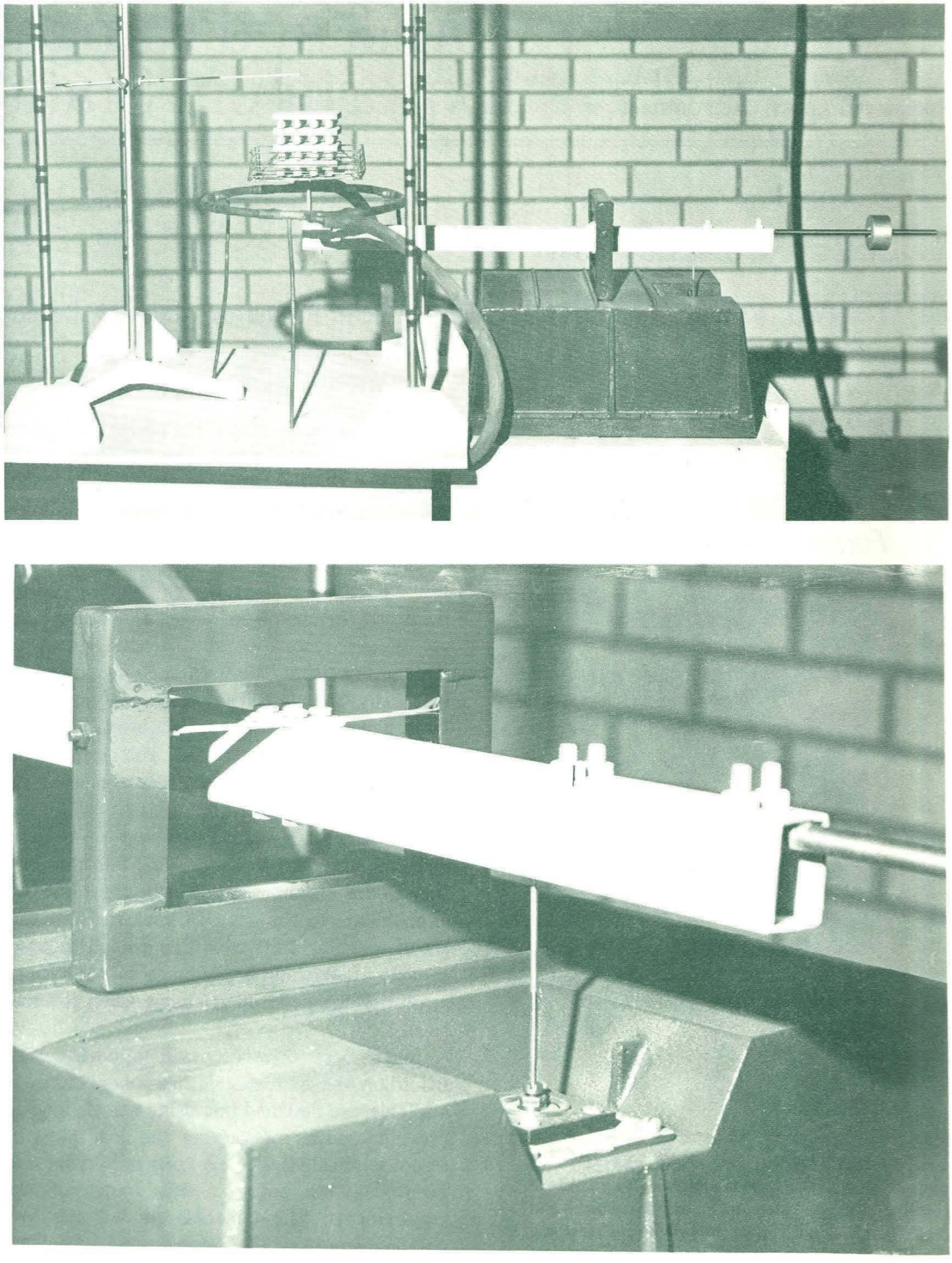


Figure 1—*Small-load cantilever scale as set up for a weight loss experiment,* top. *A torsion band is attached to the beam 18 inches from the fuel platform,* bottom. *A load cell is connected to the beam 6 inches from the torsion band.*

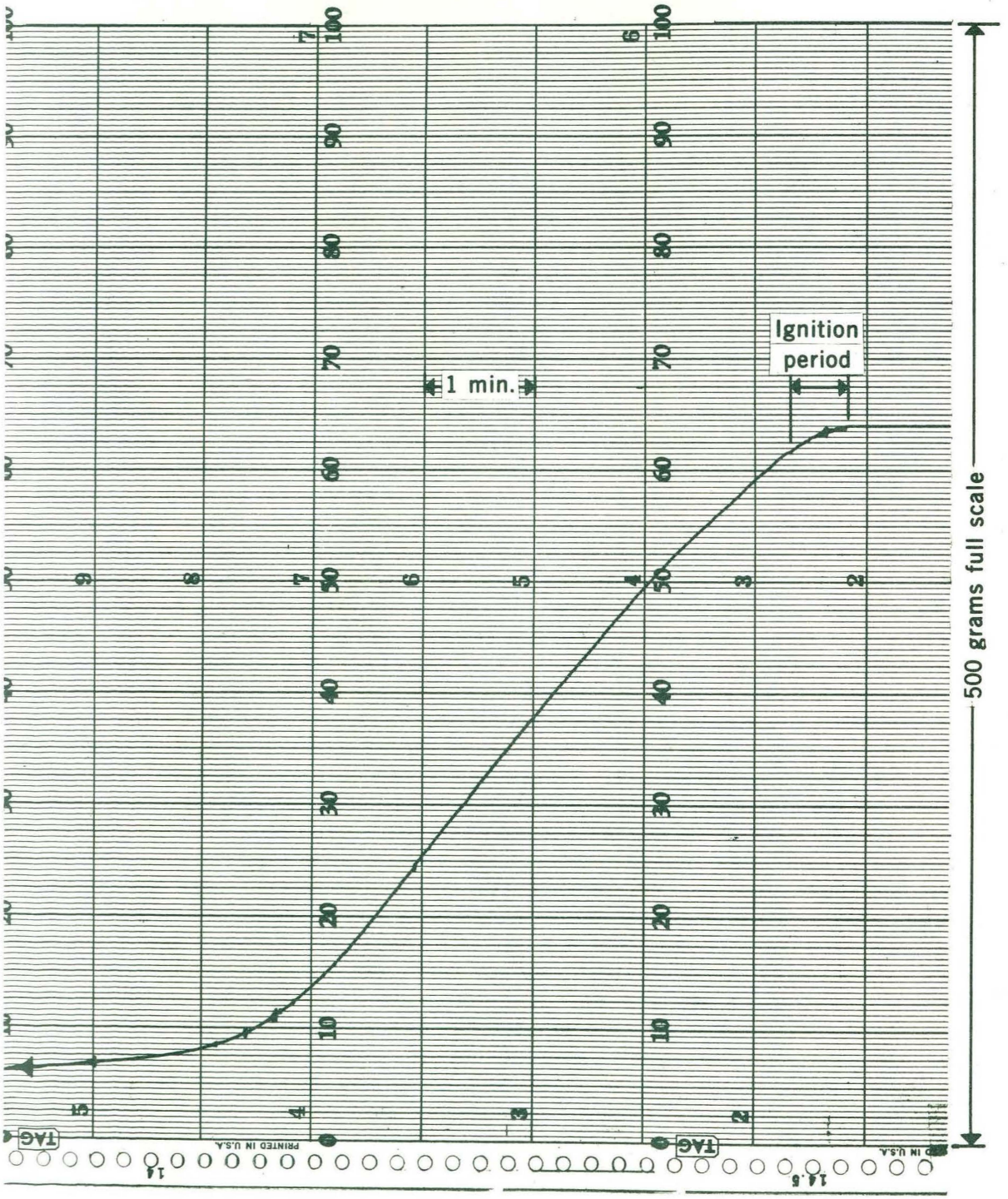
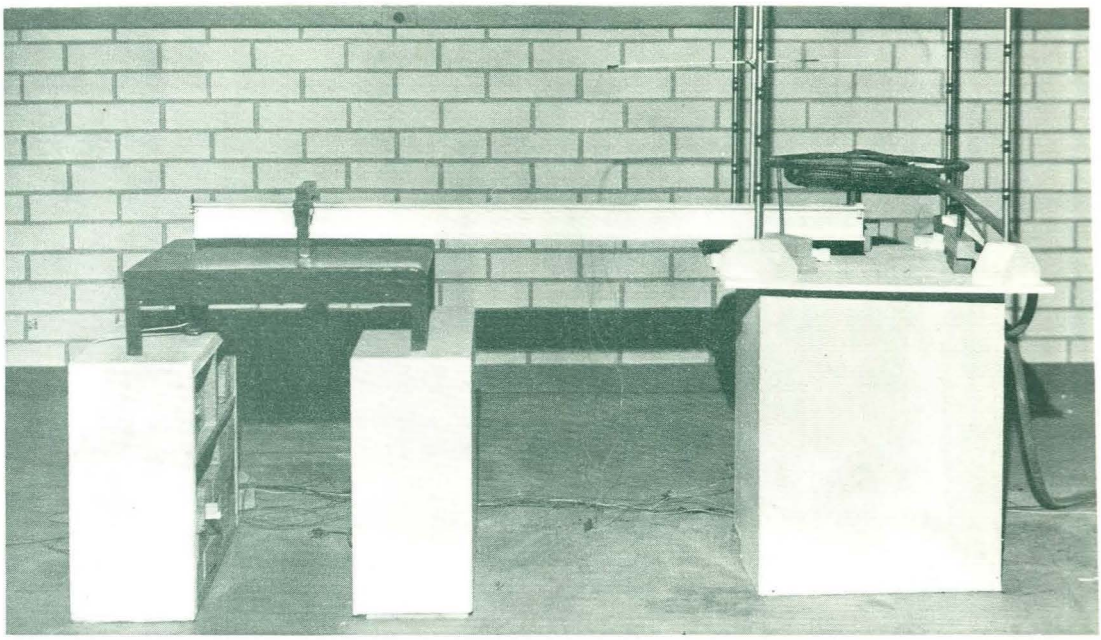


Figure 4—*Typical weight loss record from the small-load cantilever scale. Its full-scale range is 500 grams. The fuel weighed 320 grams. It was ignited by a natural gas ring burner. The small buoyancy from the burning gas is noticeable in the record during the ignition period. The small "blips" near the end of the record came from vibration as the wood crib fell apart.*



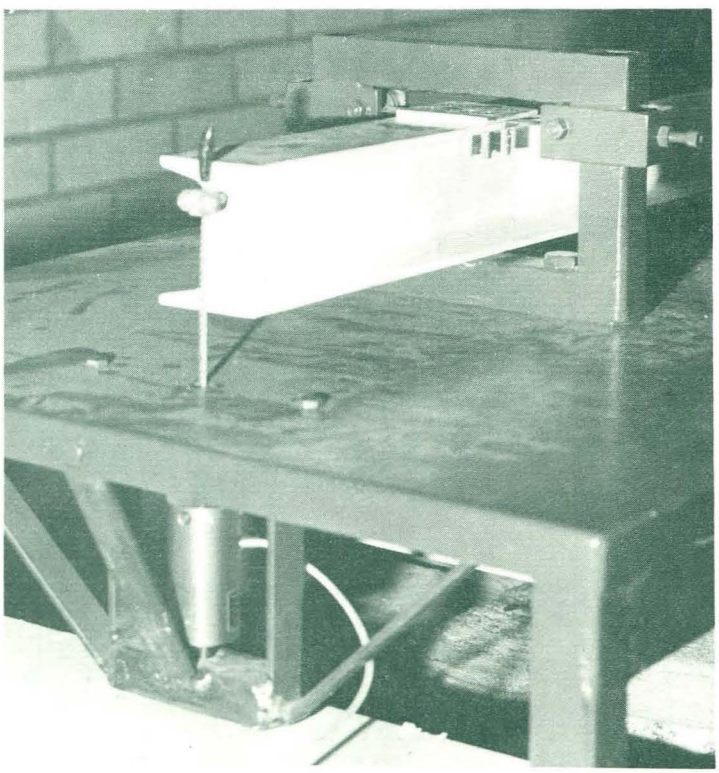


Figure 3–*Medium-load cantilever scale,* top, *has a capacity of 100 pounds. A torsion band is attached to the upright supports by a clevis arrangement,* bottom.

CANTILEVER BEAM

The device consists of a horizontal cantilever beam supported at a selected fulcrum point by a torsion band or bar. A tension type load cell is connected to one arm of the beam and a platform for supporting the fuel to the other. Two of the three devices have been built for use in laboratory fire studies.

In the first unit *(fig. 1)*, the cantilever beam is a 1- by 1½-inch aluminum tube, 30 inches long. The torsion band is a strip of stainless steel, 0.620 inch wide and 0.018 inch thick. It is attached to the beam 18 inches from the fuel platform end by an aluminum plate and four bolts *(fig. 1)*. Eye bolts, welded to the torsion band and inserted through the upright supports, provide a means of applying tension to the band. The load cell used in this unit has a rated capacity of 10 pounds. It is connected to the beam by a steel rod at a point 6 inches from the torsion band. A threaded rod with a movable weight was attached to the load cell end of the beam *(fig. 1)* to balance out the platform and beam weight on the other side of the fulcrum. This attachment is not essential, however, since the weight can be removed electronically from the indicated weight.

With the fuel platform at the end of the beam the weight capacity is reduced to about one-third of the rated load cell capacity, and the sensitivity to weight changes increased accordingly. By placing the fuel at different points along the beam it is possible to vary the weight capacity and sensitivity.

ELECTRONIC CIRCUITRY

The electronic circuitry for the weighing device is simple *(fig. 2)*. The current control on the power supply is used to adjust the full-scale deflection of the recorder pen to indicate the weight desired. The adjustable potentiometer is used to set the zero on a recorder chart, and to remove the tare weight from the record. The recorder used is an Esterline Angus Speed Servo with a 10-inch wide chart. Any potentiometer-type recorder can be used provided it has a relatively fast response time. With the Esterline recorder a change in weight of 0.5 percent of the full scale value can be detected. The minimum full scale weight setting for this unit was about 200 grams (0.44 lb.). Lesser full-scale settings resulted in a record that was difficult to interpret because vibration of the beam and minor power fluctuations greatly affected the recorder trace. Fuel loads as small as 10 grams (0.022 lb.) were burned successfully with the 200-gram full scale setting.

UNITS FOR HEAVY LOADS

The second laboratory unit *(fig. 3)* was constructed for heavier loads. The cantilever beam for this unit is an aluminum I-beam, 2.35 inches wide, 3 inches deep, and 60 inches long. The stainless steel torsion band was 0.560 inch wide and 0.020 inch thick. It was attached to the beam, 10 inches from the end, with an aluminum plate and bolts threaded directly into the flange of the I-beam. For this unit the torsion band was fastened to the upright supports by a clevis arrangement *(fig. 3)*. This permitted adjustment of the vertical position of the beam as well as tensioning the torsion band. A stainless steel cable connects the load cell to the end of the beam. The cell has a capacity of 100 pounds. The fuel platform at the end of the beam reduces the load capacity to about 20 pounds, but the sensitivity of the scale is greatly increased. The same electronic circuitry and recorder are used with this unit as with the smaller one, and a weight change of 0.5 percent of the full-scale weight setting on the recorder can be detected. The minimum full scale weight setting for

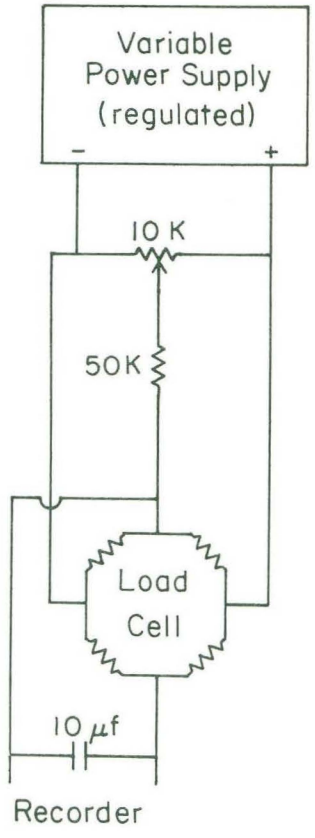


Figure 2–*Electronic circuit for the cantilever scale. All units use the same circuitry.*

this unit has not been determined. However, excellent records were obtained with a setting as low as 700 grams (1.54 lbs.).

Another unit with still greater weight capacity was built for outdoor use. The cantilever beam used was 5- by 8-inch I-beam of 3/8-inch steel, with a total length of 12 feet. Because of the weight, a torsion bar rather than a band is used to support the beam. The torsion bar was fabricated from a car rear axle and is 1 inch in diameter. It is clamped to the beam at a point 3 feet from one end, and projects about 6 inches from the edge of the beam on each side. A load cell with a capacity of 3,000 pounds is connected to the beam by a steel cable. The beam supports and load cell are anchored to concrete footings. This weighing unit also uses the same electronic circuitry and recorder as the other two units. And weight changes as small as 0.5 percent of the full-scale setting can be detected.

The minimum full-scale weight setting has not been determined for this unit. Because of the beam and platform weight, the maximum fuel load is about 700 pounds, with the fuel platform at the end of the beam. With full-scale deflection of the recorder set at this weight, good weight loss records can be obtained with fuel loads as small as 100 pounds.

PERFORMANCE

All three units have performed very well in operational use. They were calibrated with known weights, and the response to weight changes was found to be essentially linear. However, the fuel must be uniformly distributed around the center point of the platform for accurate results. The calibration is checked at a few points before each weight loss experiment. To avoid accidental overloading, we blocked the beams while placing the fuel in place and when the scale is not in use. A typical weight loss record is shown in figure 4.

The weighing units described were constructed from materials on hand and to fit the load cells available. With only three load cells, fuel loads from 10 grams (0.022 lb.) to 3/8 kilograms (700 lbs.) can be burned.

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